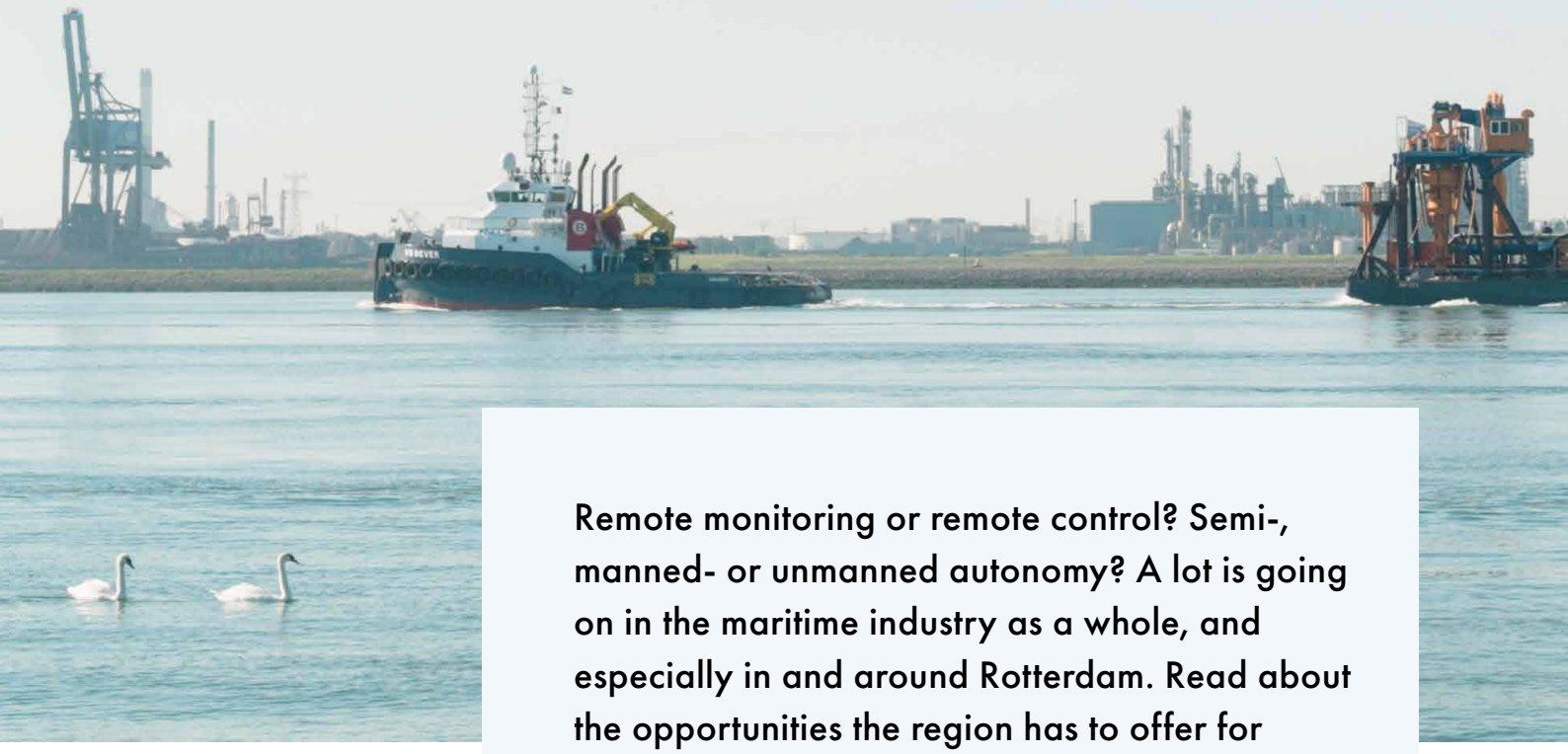
WHITEPAPER

Autonomous Shipping Technologies & Opportunities

2023 UPDATE ON DEVELOPMENTS IN THE ROTTERDAM REGION



Remote monitoring or remote control? Semi-, manned- or unmanned autonomy? A lot is going on in the maritime industry as a whole, and especially in and around Rotterdam. Read about the opportunities the region has to offer for advancing your business and ideas.

ROTTERDAM.
MARITIME CAPITAL OF EUROPE.

Supporting Autonomous Shipping

"Having ran my own inland shipping company for years, dealing with its risks, costs and effects, I set out to make sailing easier, safer, more environmentally friendly and especially smarter. There's so much temporary and unused data on any vessel, it's incredible. Our 'Shipping Technology Brain', as we call it, unlocks those data and uses them for navigation, emission reduction, incident prevention and reporting and, in the end, autonomous sailing. When we were ready to experiment with, for example, our Autonomous Lane Assist hardware and software, we were pleasantly surprised by the help we got from the Port of Rotterdam Authority, government agencies, research institutes, insurers, maritime lawyers and investors. That's a big reason why we are now scaling up. The regional maritime ecosystem here is definitely an enabler."

Captain Remco Pikaart
Founding partner at Shipping Technology

"The world of marine legislation, certification, risk analysis and insurance is quite complex; even more so for technologies that currently lack a fit-for-purpose legal framework. As an underwriting and insurance company we take care of both large businesses and start-ups by covering possible financial consequences should their remote-controlled or autonomous sailing experiments lead to any accidents or damages. This provides these companies with the necessary room to experiment."

Anneke Kooiman
Associate Director Technique Marine at DUPI underwriters

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Autonomous Shipping Innovations Thrive in Rotterdam

In recent years, the global maritime industry has witnessed a surge in (the wish for) innovative autonomous and remote-controlled shipping technologies. But it's often not easy to get funding, insurance or even permission to set your drone, onboard hardware or software to work where it belongs: on the river, in the port, out at sea. So, how is the situation in the greater Rotterdam port area in 2023? Here's an update.

Australia, China, Finland, the Netherlands, Nigeria, Norway, South-Africa, South-Korea or the USA – you can see experiments popping up everywhere. These advancements are not only shaping the future of shipping but also provide opportunities for 'tech-heavy & savvy' regions to become a hub for cutting-edge maritime solutions.

The Netherlands , especially the Rotterdam region have stepped up to this challenge and attract people and organisations from around the world who see technological or commercial opportunities to start or expand their business. Already, experiments are running in several areas, such as commercial shipping, defence & security, hydrography, offshore, scientific research and yachting.

DRIVING FORCE: PORT OF ROTTERDAM AUTHORITY

At the forefront of autonomous shipping initiatives, the Port of Rotterdam Authority has been actively testing autonomous navigation and berthing technologies. Their primary goal is to enhance the efficiency and safety of port operations. Collaborating with tech companies and research institutions, the Authority is pioneering with automated solutions that promise to revolutionize maritime logistics. In addition, they support third parties, e.g. with funding, collaboration, permission or locations.

DIVE INTO THE ECOSYSTEM

For those looking to experiment with (semi) autonomous drones, ships or platforms or wanting to validate technology, here's a list of Dutch companies already involved in ongoing projects: Aquatic Drones, Captain AI, Demcon Unmanned Systems, Damen (Fieldlab Autonomous Sailing Technology), Holland Shipyards Group, Lobster Robotics, Shipping Technology, RoBoat.

Note that this overview is by no means exhaustive – there are many others with have a keen interest in developing and testing autonomous solutions who are, on their own or in collaboration, pushing the boundaries of maritime technology. Nice to know: most of the people working on these projects are happy to engage in talks with interested parties, even when they are competitors.

It's also a good idea to get in touch with specialist organisations and associations such as SMASH (the Netherlands Forum for Smart Shipping), RAS Delft (Research Lab Autonomous Shipping), Autonomous Shipping (Joint Industry Project), NMT and of course Rotterdam Maritime Capital of Europe.

They can tell you more about current developments and get you in touch with relevant people in relevant organisations, incl. universities, manufacturers, regulators, insurers, investors etc. – all those institutions who make up the ecosystem surrounding your technology, product or service.

MARITIME MASTERPLAN

Recently, the Dutch maritime industry and the government have presented the Maritime Masterplan: a roadmap to build at least 40 zero-emission vessels before 2030. A subsidy of 210 mln EUR was granted to the industry in June 2023 to speed up this process. While many of these projects are about alternative fuels, environmentally friendly propulsion systems and emission-free production methods, several of them go hand in hand with data-analysis, remote monitoring and autonomous sailing technologies.

SCIENCE AND RESEARCH

Several renowned research institutions and universities are actively involved in autonomous ship technology research. Delft University of Technology is a good example, but also the Rotterdam School of Applied Sciences and research institutes MARIN and TNO, who play an important part in validating new technologies.

These institutions collaborate with industry partners to explore various aspects of autonomous shipping, such as navigation, safety, communication or propulsion. Their work contributes to the knowledge base that fuels innovation in the region.

PROJECT TYPES

Numerous pilot projects in the Rotterdam region exemplify the commitment to testing and advancing (semi)autonomous shipping technology. These projects involve retrofitting existing vessels with autonomous systems and constructing autonomous vessels from scratch. There are several big (e.g. ferries, inland shipping or naval vessels) and small (e.g. survey or waste disposal drones) projects, some of which are already viable commercial products.

The region's waterways provide an ideal testing ground for these pioneering projects and the Port of Rotterdam Authority and the Ministry of Infrastructure and Water Management are opening up more and more ways to (literally) give room for testing.

CHALLENGES

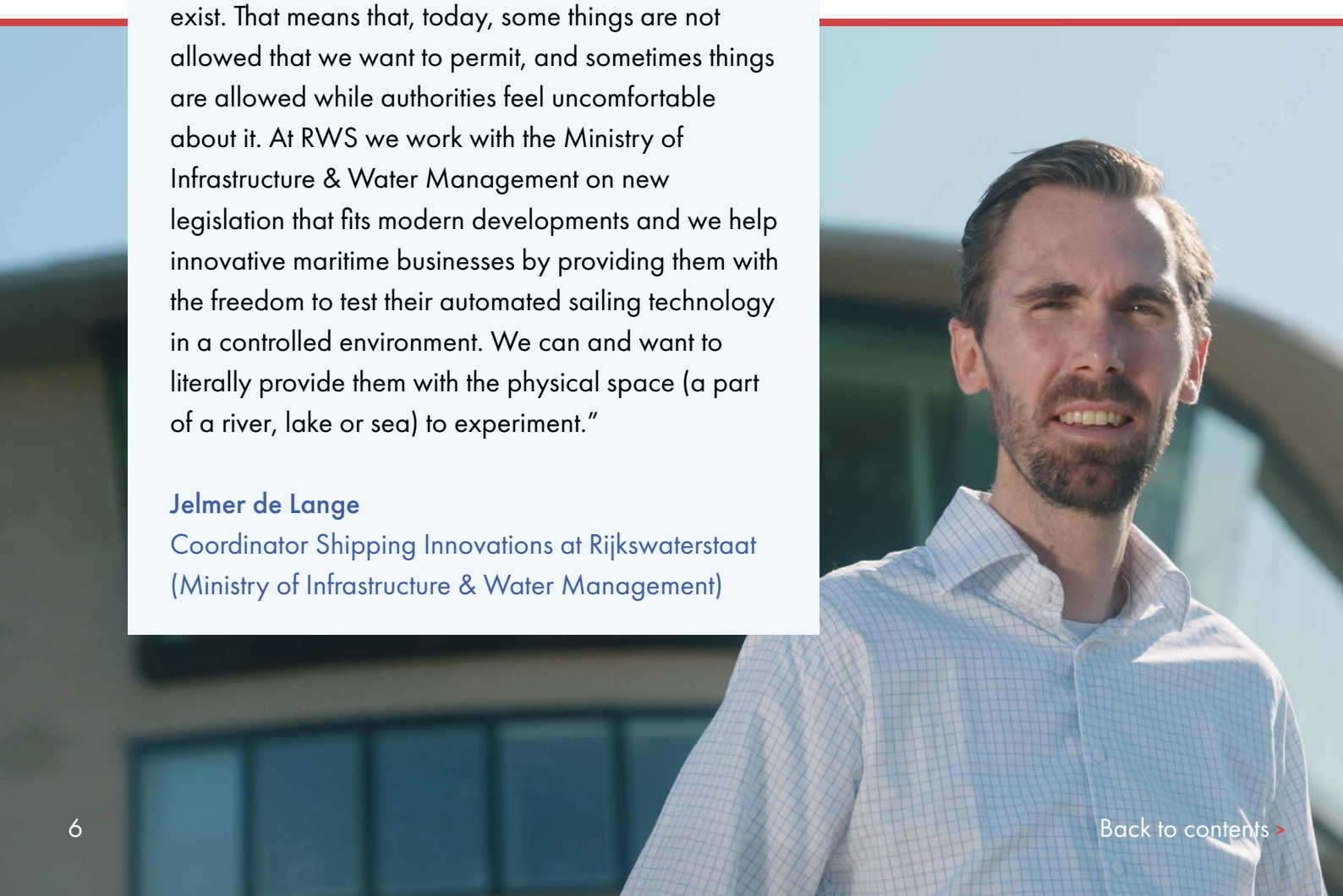
While there are many positive developments, there are, of course also challenges, both as to the technology as to rules, regulations and support systems. In the rest of this whitepaper, we'll be looking at these developments. For this we interviewed Jelmer de Lange from Rijkswaterstaat, Anneke Kooiman from DUPI Underwriting Agencies and Remco Pikaart from Shipping Technology, a company developing autonomous sailing software and hardware.

For now, it's important for you, the reader, to realize that Rotterdam and the surrounding cities and businesses are in need of technology and ideas to speed up the process of safe, efficient autonomous sailing and all that that entails.

Yes, the region is at the forefront of what can be done, but there are still pieces of the puzzle missing – and there is more than one puzzle to solve too. So, lots of room for newcomers to do business!

"Existing rules and laws can be an obstacle, because they were made when automated shipping did not exist. That means that, today, some things are not allowed that we want to permit, and sometimes things are allowed while authorities feel uncomfortable about it. At RWS we work with the Ministry of Infrastructure & Water Management on new legislation that fits modern developments and we help innovative maritime businesses by providing them with the freedom to test their automated sailing technology in a controlled environment. We can and want to literally provide them with the physical space (a part of a river, lake or sea) to experiment."

Jelmer de Lange
Coordinator Shipping Innovations at Rijkswaterstaat (Ministry of Infrastructure & Water Management)



Are you ready for the future of the Maritime Industry?

Rules & Regulations

The Netherlands have spent hundreds of years on developing technologies that aim to control and use water as a resource for many goals, e.g. safety, transport and drinking water.

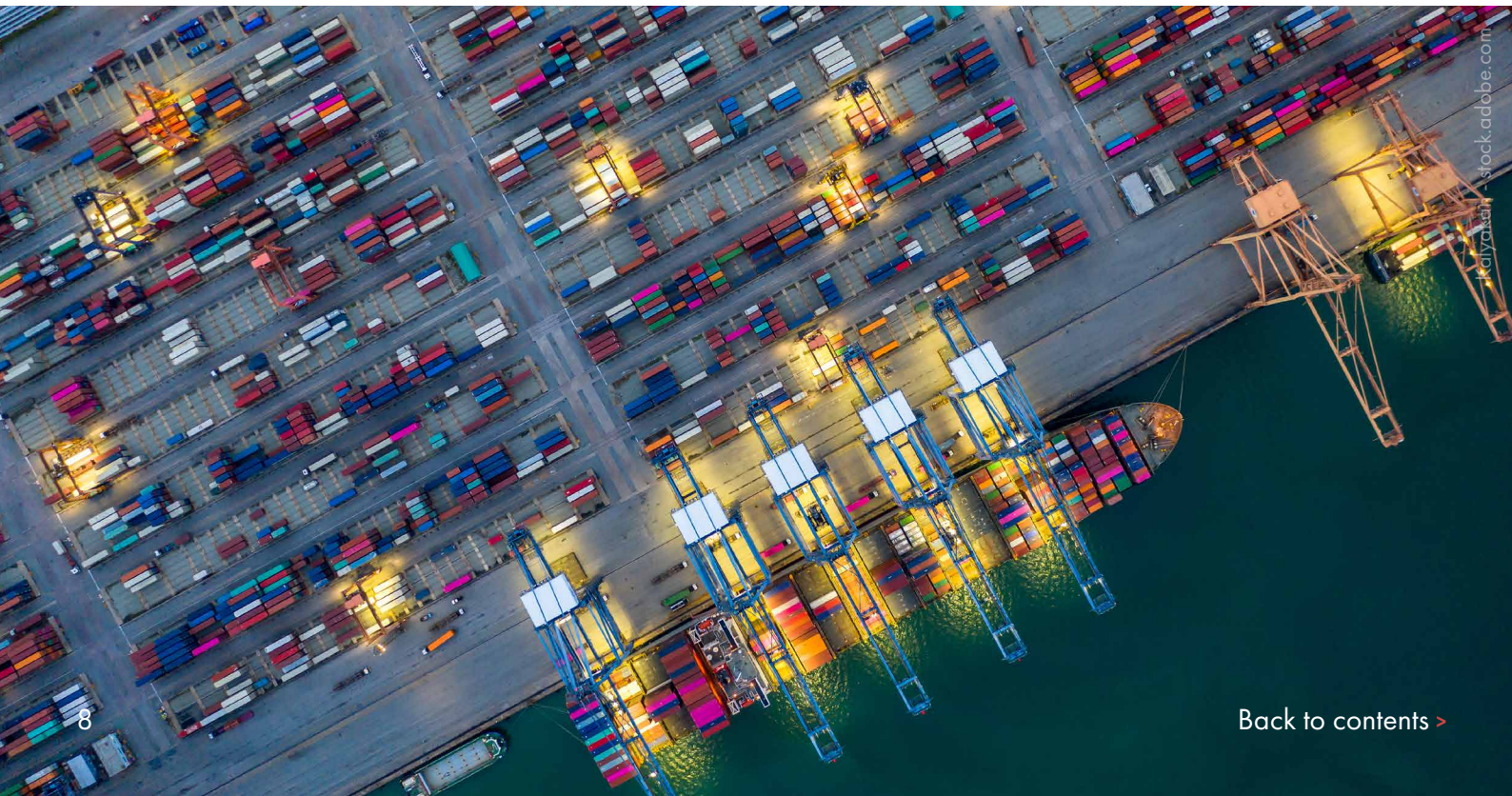
The Dutch waters are full of (manned) surface vessels. Shipping is an integral part of the economy. To fulfil its function, the Ministry of Infrastructure and Water Management (I&W) prepares policy and legislation for the safe introduction of automated shipping in the Netherlands. Rijkswaterstaat (RWS), is the executive authority responsible for the national waterways and infrastructure.

Jelmer de Lange is Coordinator Shipping Innovations at RWS. Before, Jelmer was Manager Innovation at Jules Dock, developing (composite) materials and products for bridges, offshore wind turbines, amphibious vessels, tank testing etc. Now, he is part of the team that facilitates test and demonstration permits and participates in SMASH!, the Dutch network for smart shipping, in which stakeholders come together and share knowledge.

REGULATORY FRAMEWORK

"Rules and laws can be an obstacle", says Jelmer, "because they were created when automated or unmanned shipping didn't exist. So, the first thing we did was to **create legal space for experimentation on public waters.**"

Since 2019 the Dutch government works with a set of policy rules for the inland waterways and the territorial sea that allow for experiments, the Policy rules experimentation with automated vessels.



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"This provides a smart and safe way for developing automated sailing within the boundaries of the law; it's permission to experiment, not permission to act outside the law. This means, for example, that you'll need an onboard crew during the experiment even if they don't have to do anything. **During these experiments, steering and navigation can be done by remote control or some form of AI autopilot**, i.e. a software and sensory system that decides for itself how to sail best. These experimentation permits work well for bigger ships, we receive applications all year round.

For (small) Unmanned Surface Vessels or sailing drones it's a bit different: placing crew on board is physically impossible or unsafe. The Ministry of I&W is working with RWS on new rules, meanwhile granting experiment permission to sail unmanned drones that can be remotely controlled within eyesight distance - if the safety of others is guaranteed. **'Presenting no danger or delay' to the surrounding area is a key element in this approach**, with which the Netherlands are ahead of most other countries.

The Dutch approach offers quite a bit of freedom. Jelmer: "There's no track record for automated ships; the technology is being tested to gather proof. Hence we have to take calculated risks. The current experimentation policy allows for that while companies can test and demonstrate technology on real waters.

REGIONAL COLLABORATION

Rijkswaterstaat collaborates closely with the Port of Rotterdam Authority and the Coast Guard, as each has their own responsibilities. "Small automated survey vessels are interesting for offshore inspection work, but can never be allowed to endanger the large ships and the port's operations. Together we are looking for ways to create circumstances in which they could operate or transfer unmanned in the port's basins and waterways."

Speaking regularly with the innovators provides us and them both with useful insights.

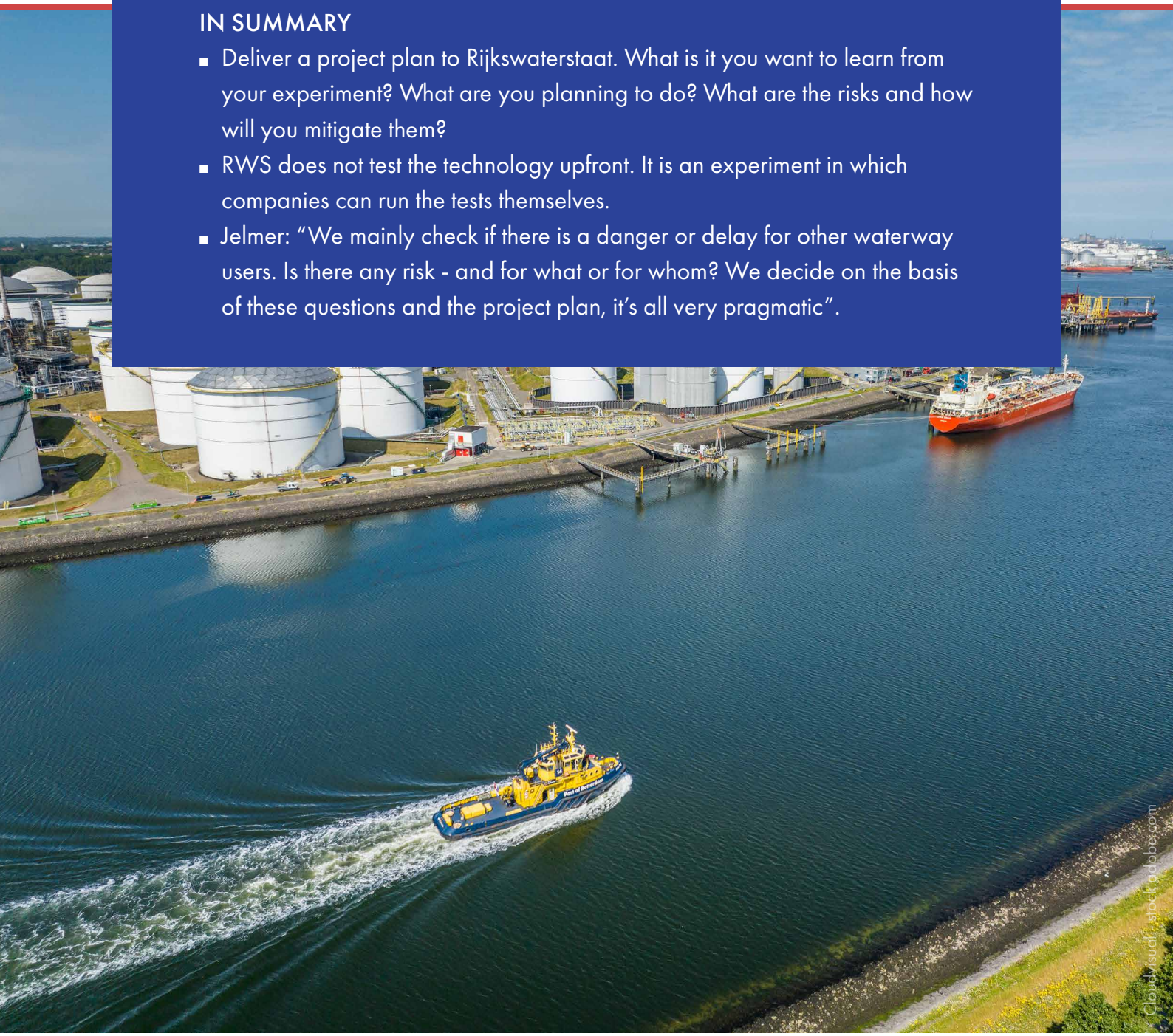
We use those insights in the ministry's Smart Shipping Programme. We have a team of people from various departments who focus on policy development and new regulation and also are involved in incoming requests for experiments and what that means for incident management, locks, bridges etc."

HOW TO GET APPROVAL FOR YOUR TEST?

Bottom line: **there's ample room to do what you want and it is fairly easy to ask for permission** from the fairway authority, as long as the project is in line with current regulations and the safety of other waterway-users is guaranteed.

IN SUMMARY

- Deliver a project plan to Rijkswaterstaat. What is it you want to learn from your experiment? What are you planning to do? What are the risks and how will you mitigate them?
- RWS does not test the technology upfront. It is an experiment in which companies can run the tests themselves.
- Jelmer: "We mainly check if there is a danger or delay for other waterway users. Is there any risk - and for what or for whom? We decide on the basis of these questions and the project plan, it's all very pragmatic".



SMASH! VS LEGISLATION

"The partners in the SMASH! network have all chosen to gather information, share knowledge, publish, organise events, represent the Netherlands, get new people into the network and, importantly, discuss about rules and regulations", Jelmer states. "**It's an open and pre-competitive organisation** and in effect, when you are a SMASH! partner, you can directly get in contact with ports, national authorities and ministries and therefore influence new legislation."

Insurance

Anneke Kooiman, Associate Director Technique Marine at DUPI Underwriting Agencies, sees several advantages of (semi) autonomous vessels, a major one being the fact that the systems that enable autonomy provide a wealth of (extra) data about a ship's behaviour and performance – and that is interesting when you have to provide insurance for such a vessel. Risk inspections, analyses and preventive measures all benefit from such systems.

"Of course, there are some big, international obstacles to overcome, especially clear and unified legislation", she says, "but still, we see a lot advantages, not in the least for inland shipping and public transport on fixed routes. It will become safer, as human error will significantly be reduced and there will simply be less accidents. It will also reduce cost significantly."

CHALLENGES

Anneke: "We expect an increase in cyber-attacks once remote-controlled and autonomous vessels become a regular sight on the high seas. So, cyber security, wifi connections and IoT-device protection become even more important."

Another obstacle: insurance agencies are not allowed to collaborate – they have to compete. "The International Union of Marine Insurers does play a positive, integrative role. On the IUMI website, you can find several publications on the topic."

There are also several questions and 'unknowns' that insurance agencies will have to think about and create first-generation solutions for – proactively, if it's up to Anneke.

"How will piracy change, for example? There's no security on board. Also, taking evasive action will have to be done in a very different way. Salvage operations will change: when a salvage team boards a grounded ship, for example, there's no one on board who can say anything about the preceding circumstances or the state of the vessel. How is that going to play out? Who's going to do small repair and maintenance jobs during long voyages? And if they don't happen and cause damages, even very small damages, who is responsible? Solving insurance issues is and will remain an interplay between stakeholders, but the 'claims-game' *will* change."

Another 'unknown' is **how the interaction of various technologies will play out**. "Take for example inland shipping barges transporting, say, beer in city canals. These barges sail on fixed routes in a well-known environment, in principle perfect for automation. The electricity powering their propulsion systems comes from containerised batteries. These contain gauges measuring jolts. When they measure a non-standard impact, they new containers

are not allowed to be taken on board and first have to be surveyed. With on-one on board, this would take much time and serious delay delivery schedules every single time. And what about fires breaking out?"

For the short and mid-term, Anneke thinks the solutions can be found in semi-autonomous sailing, as this would solve a huge amount of the problems that full-autonomous shipping poses. Having a (limited) crew on onboard can also take away many concerns from legislators.

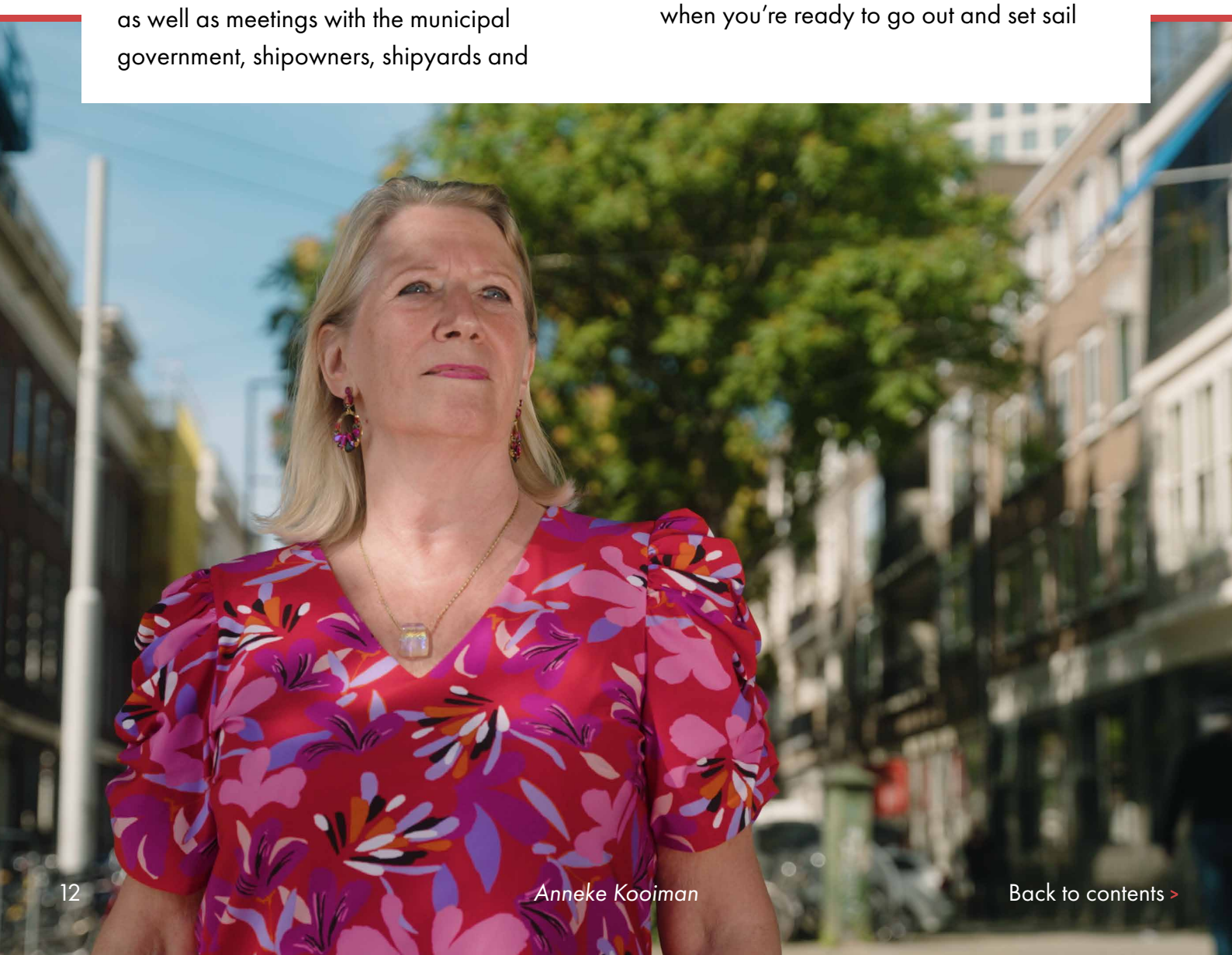
WHAT'S HAPPENING IN ROTTERDAM TO ADDRESS THESE ISSUES?

"We often join the sessions at SMASH!, where stakeholders discuss these topics, as well as meetings with the municipal government, shipowners, shipyards and the IVR, the association for vessels on the Rhine River, to formulate solutions together, especially to basic questions like '**Who will be responsible?**'. There's a lot of knowledge here and insurance agents have to analyse proactively what their role should be."

TIPS FOR BUSINESSES

A lot is being done to enable experiments of all sizes. It all depends on your product or ship type how you want to deal with insurance, but in general, these two steps are good advice, according to Anneke Kooiman:

- For start-ups: find a good intermediary, a reputable insurance broker who has already delved into this area of expertise
- Get your insurance company in at an early stage, so that there won't be any surprises when you're ready to go out and set sail



Anneke Kooiman

Practice: every ship a smart ship

How does all of the above take effect in practice? Remco Pikaart, a former inland shipping business owner and captain, founded Shipping Technology when he kept being surprised by the way vessels produce tons of data, that are then not used on an aggregate level to help make predictions for the short term (navigating a waterway) or the long term (commercial, maintenance, safety).

Under the slogan 'every ship a smart ship', he built hardware and software, his 'Shipping Technology Brain'. The 'brain' gathers all data and unlocks them in a meaningful way. That is, a way that turns regular ships into automated ships based on data analysis, machine learning and specialist hardware.

"With this combination, we can retrofit any ship", Remco says. "This is important, because **the future of autonomous shipping cannot only consist of newbuilds**; it would take ages to replace all existing vessels. And we need solutions now. Shipowners want to be ready for the future."

The current system controls the rudder, allowing for 'hands free' sailing, but it gathers more data and makes those useful for other purposes too. "These are cloud services providing real-time insights in performance, both on board as on land, at one's office desk. We've used the data we need for developing the autonomous sailing tooling to also build an Emission Module that is now being validated by research institute TNO and Lloyd's Register. Our Incident Reconstruction Module is up and running and a Predictive Maintenance tool is coming up."

"As we currently have about 200 Dutch, German, Belgian and Portuguese clients, we receive huge amounts of data to improve these tools fast. We also use them to train, for example by analysing heat maps of the most common near misses. In fact, due to the performance monitoring data and the resulting enhanced safety, there's already an insurance company *returning 50%* of our subscription fee to the client. *That's* how satisfied they are with this system."

CREW: HISTORY OR NECESSARY?

"Our **Autonomous Lane Assist** system controls the rudder. Soon we will integrate it with engine management and in a later stage also hook-up the bow thruster to achieve full autonomy. However, to make a commercially viable business case that is also acceptable for the legislator will take years. The technology will be there and at a higher level than today, but real, 100% autonomous sailing goes far beyond technology. **The physical, judicial, economic, commercial and social context is complex** and can also differ per country, per region even. I expect that for

years to come, even if it is not necessary from a technical point of view, ships will have crew on board. Their roles may change, but we can't do without them."

REMOTE CONTROL?

"About 75% of all accidents on the water are related to human error or neglect", says Remco. "Even experienced captains and helmsmen can make mistakes. So, I'm a bit sceptical about people saying that in the near future captains will work in an office, looking at screens, video-images and digital tools and controlling five, even ten vessels *at the same time*. If you're navigating through busy shipping lanes, for example, you'll need all your attention to run one ship, let alone five. That said, the tools for remote control and monitoring can make for a safer, more efficient, less costly shipping industry. Shipping, surveying and marine maintenance as we know it will change, no doubt about it."

Remco continues: "As developers we have a responsibility to help take the market to the next level, to explain, to ready the market to adapt its business models. These changes do not have to be disruptive per se, but we do need to embrace them in order to move ahead and stay relevant."

WHY ROTTERDAM?

"Rotterdam is simply the maritime capital of Europe and the whole region radiates 'shipping'. Everything you need is close at hand: marine lawyers, insurance companies, technical suppliers, repair yards, investors, you name it, it's here. This region is also the epicentre of the European inland shipping industry. Rijkswaterstaat is near to our office, as is the Port of Rotterdam Authority, which is practical when you're engaged in the process of obtaining permits and locations to experiment."

COLLABORATION

According to Remco, his clients are eager to collaborate, which is great for further developing the system. "They really think with us about which tooling and which types of data are needed. The same goes for Rijkswaterstaat. I met them originally at SMASH! events, when I was still a member in my capacity as captain-owner of a ship. Now, with Shipping Technology, they literally ask us how they can facilitate our experiments. They are an open-minded team."

TRANS-REGIONAL DEVELOPMENTS

These developments are not confined to Rotterdam alone. Partnerships and initiatives across the Netherlands are propelling the nation to the forefront of autonomous shipping technology.

As the world looks toward a future with autonomous vessels Rotterdam and the Netherlands are poised to play a leading role in shaping this transformative industry.

Private and public organizations are driving innovation and fostering collaboration within an ecosystem that encourages research, innovation and engagement. Setting sail towards a smarter and safer maritime future.

Rotterdam Maritime Capital of Europe

Rotterdam's regional port cluster, and wider Maritime ecosystem, is home to one of the most complete, integrated and innovative Maritime networks in the world. Our goal is to work together on pioneering solutions that contribute to the sector's energy transition, digitalisation and circular economy.

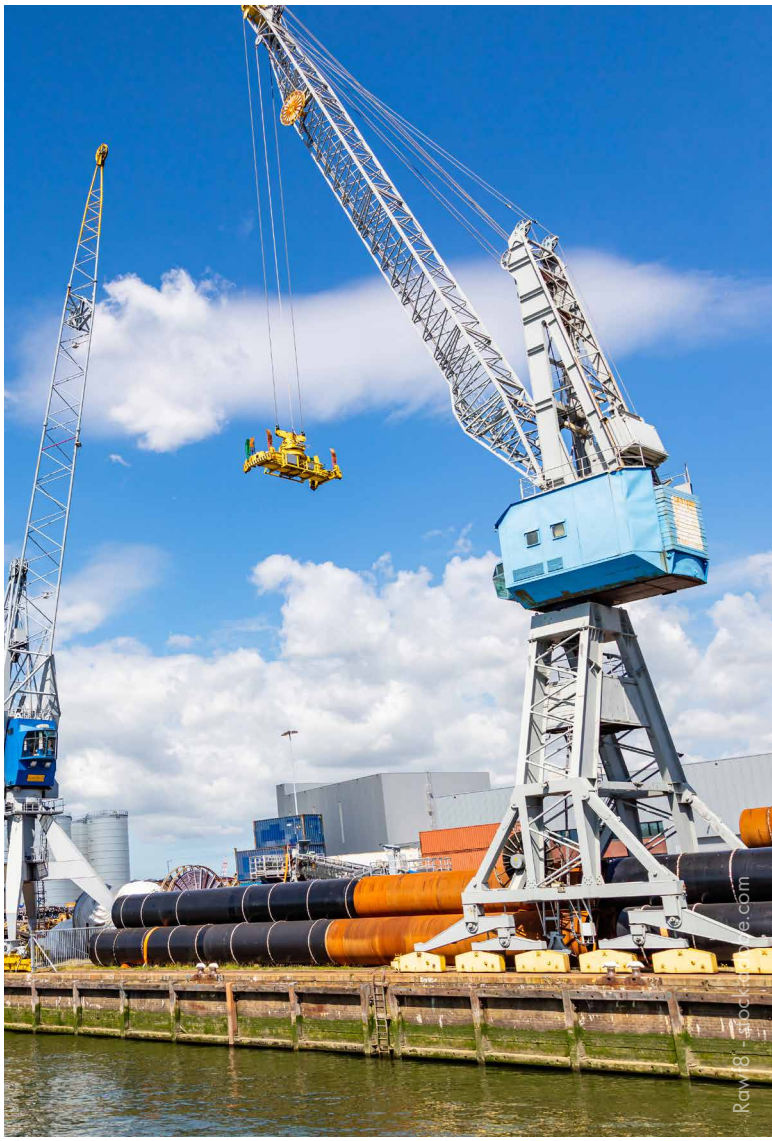
Have a look at the Rotterdam Interactive Transition Map. It shows 70+ projects aiming to achieve a CO2-neutral port.

To achieve our ambitious decarbonisation goals, we team up and pull resources to create the most innovative and sustainable maritime cluster in the world. And you can become part of it too.

DO YOU WANT TO BE PART OF THIS?!

Is your company active in the maritime, offshore, port or energy industries, then contact us today! Reach out via maritime@rotterdam.nl or visit rotterdammaritimecapital.com.

Our specialists will answer your questions and/or get you in touch with partners and stakeholders that will help you 'set up shop'. We're here for you!



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